CONTRIBUTIONS TO PALEONTOLOGY

I

A TERTIARY MAMMALIAN FAUNA FROM THE AVAWATZ MOUNTAINS, SAN BERNARDINO COUNTY, CALIFORNIA

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With six plates and three text figures

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INTRODUCTION

The Tertiary mammal occurrence in the Avawatz Mountains, discovered in 1932 by the late H. W. Nickerson of Yucca Grove, California, was reported first to the Los Angeles County Museum. W. M. Strong, sent out by the Museum to make a survey of the area, assembled a small collection, but the material was so fragmentary that interest subsided. Subsequently, in 1935, in the course of archæological field studies, Mr. and Mrs. William

FIG. 1—Locations of upper Miocene and lower Pliocene vertebrate fossil localities of the western United States.

H. Campbell of Twenty-nine Palms rediscovered the fossiliferous locality on the south flank of the Avawatz Mountains. The occurrence was brought to the attention of E. L. Furlong, who visited the region with Mr. and Mrs. Campbell. Most of the material now in the collections of the California Institute of Technology was acquired during these visits. Since then, several brief collecting trips have been made to the area.

The significance of the discovery of fossil vertebrate material in the Avawatz Mountains becomes at once apparent when it is recognized that herein lies a clue to the dating of at least some of the tremendous diastrophic activity which has spasmodically convulsed the western portion of the Great Basin during later Tertiary time. This point will be discussed further in the section dealing with the geological observations.

My sincere thanks are extended to Mr. and Mrs. W. H. Campbell for their wholehearted cooperation in obtaining the collection. I am deeply indebted to Dr. Chester Stock for his continued interest, invaluable counsel, and critical reading of the manuscript. The guidance and advice of E. L. Furlong, who assembled the bulk of the collection, of R. W. Wilson, who studied and described the Avawatz rodents, and of J. R. Schultz are acknowledged with gratitude. J. F. Dougherty, A. B. Drescher, and G. A. Rynearson of the California Institute of Technology ably assisted in collecting material. For their courtesy, cooperation, and helpful suggestions I am greatly obligated to the staff of the University of California, especially to J. T. Gregory, R. A. Stirton, and V. L. Vander Hoof. The illustrations were prepared under the direction of John L. Ridgway.

LOCATION

The fossil material in the collection from the Avawatz Mountains was found at California Institute of Technology Vertebrate Paleontology Locality No. 267. The locality lies on the southeasternmost flank of the Avawatz Mountains, ten miles by road northwesterly from the town of Silver Lake on the Tonopah and Tidewater Railroad (see fig. 2).

RÉSUMÉ OF GEOLOGIC OBSERVATIONS

In the geologic literature no reference has been made to the Tertiary sediments exposed at the southeastern end of the Avawatz Mountains. It is not within the scope of this paper to present a detailed account of the stratigraphical and structural relations of these sediments. However, a brief areal survey has brought out a few major facts.

Stratigraphy—As at many other localities in the Mohave Desert, the rocks of the southeastern portion of the Avawatz Mountains may be divided into three groups: (1) the basement complex of metamorphic and plutonic rocks, (2) the superjacent series of sedimentary rocks, and (3) the alluvium (Baker 1911, 1912; see Literature Cited at end of this paper). The basement complex outcrops only on the high central portions of the range. Lapping far up onto the range, and forming some of the high peaks and ridges, are the sedimentaries. Alluvium, which at present is being vigorously dissected, lies on the lower slopes across the beveled edges of the older sedimentaries. Away from the mountains, a younger alluvium is accumulating on the great fans and in the playas.

Basement complex of metamorphic and plutonic rocks—No attempt is made to unravel the complexities of the basement which comprises the core of the Avawatz Mountains. However, judging from their outcrops, rock types occur which are potential sources for most of the boulders of the Tertiary conglomerates. These include quartzite, dolomite, marble, schist, gneiss, granite, and several types of darker igneous rocks, including one coarse-grained gabbro, which is composed to a large extent of hornblende. The basement consists of intimately associated small masses of these various rocks.

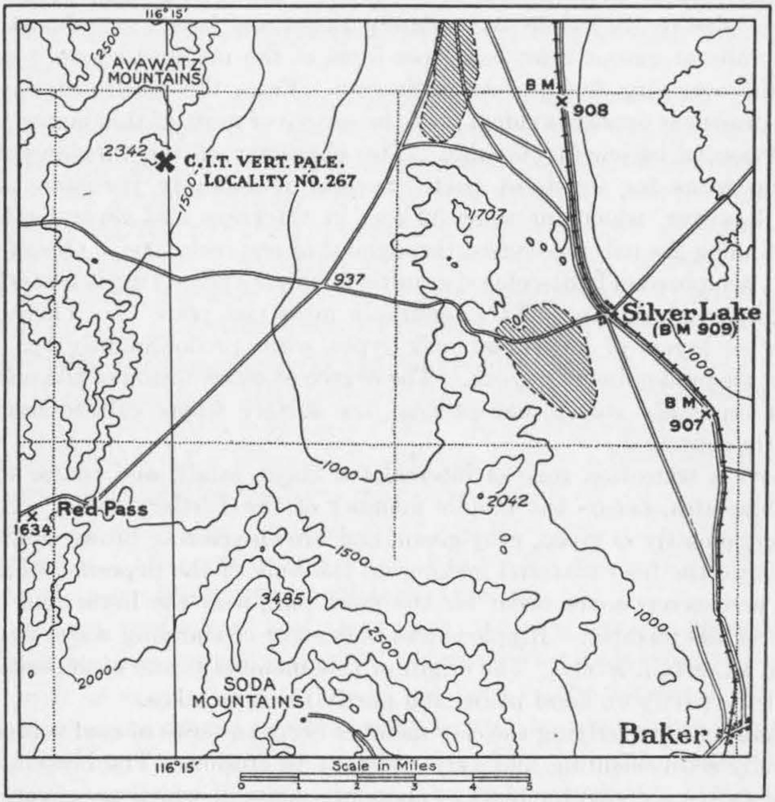

FIG. 2—Southeastern portion of the United States Geological Survey Avawatz Mountains Quadrangle showing the location of the California Institute vertebrate fossil locality in the Avawatz Mountains. Contour interval, 500 feet.

Overlying series of sedimentary rocks—Unfortunately any attempt to correlate stratigraphically the Tertiary sediments of the Avawatz Mountain area with those of other parts of the Mohave Desert region meets with considerable difficulty. Following the precedent established by J. C. Merriam in giving local formational names to the Barstow and Ricardo, the name Avawatz formation is proposed to include the Tertiary series which lies immediately to the south and west of the eastern end of the Avawatz Mountains. The lack of a map on an adequate scale prevented anything more than a most cursory survey of these Tertiary sediments. The formation may be roughly divided into four members: (1) a coarse conglomerate (fanglomerate), (2) green and brown clays (lake beds), (3) resistant breccia (atmoclastic breccia), and (4) arkosic sands and tuffs (fluviatile deposits).

The lower member, or fanglomerate, varies considerably in thickness, pinching out to the east and thickening to the west. Its thickness directly north of the fossil localities is well over 1000 feet, while to the west it appears to attain a thickness of several thousands of feet. The deposits are extremely coarse, and some of the boulders in this conglomeratic material measure five or six feet across. Sandy lenses and layers are almost completely absent except near the upper limit of the member where it grades into the overlying fine-grained sediments. From the nature of the rock types present it appears evident that the source of most of this material was the Avawatz basement complex. The character of the fanglomerate is heterogeneous for the most part. Several remarkably persistent layers exist, however, which for some 30 feet in thickness and several miles in extent along the outcrop consist throughout of one rock type. One of these layers, composed of light-colored granitic boulders and matrix, is remarkably well displayed, dipping off the mountain mass (see plate 1). There are a few other layers of individual rock types, some predominantly red while others are predominantly green. The degree of cementation of the material is not especially strong, except near the surface where caliche has been recently deposited.

Above a transition zone of intercalated clays, sands, and coarse to fine conglomerates, occurs the middle member of the Tertiary series. It consists dominantly of green, gray-green, and brown-green to brown fine sands and clays, the finer material making up the bulk of the deposits, while the more arenaceous zones occur for the most part near the lower and upper limits of the member. Ripple marks indicative of standing water were observed at certain levels. The origin of this member is one of deposition of sediments partly on flood plains and partly in playa lakes.

Conformably overlying the clay member occurs a series of coarse breccias, generally self-cementing and very resistant to erosion. The breccias consist of extremely angular blocky fragments, some of which are several feet across. Generally the lower part of the breccia is made up of a fine- to medium-grained, gray-green igneous rock, while gray dolomite or pure white limestone and marble form the upper part. A most remarkable feature is the constancy and uniformity of rock type composing these two separate parts of the breccia. Extremely little commingling of rock types occurs. The aggregate thickness of these breccias varies from place to place, ranging from perhaps a few tens to a few hundreds of feet. These breccias probably represent a fanglomeratic type of deposit approaching a talus breccia in character.

The uppermost member of the Tertiary formations has been considered in detail. Characterized by a predominance of arenaceous sediments over those of an argillaceous or tuffaceous character, this member is the only one in which fossil vertebrate remains have been found. Very striking in appearance are several persistent layers, a few feet thick, of pure white volcanic ash, occurring in the lower part. These vary from fissile shales made up of paper-thin laminæ to massive beds so highly indurated as to break with conchoidal fracture. Other beds which have been employed as markers include several of punky gray volcanic ash, each a few feet in thickness. The upper part of the fluviatile deposits lenses gradually into a pebbly conglomerate and finally into a coarse conglomerate. Although some of this material was deposited in still water, as indicated by occasional layers showing oscillation ripple marks, the bulk of it was laid down under flood-plain conditions.

Quaternary—Resting with pronounced angular unconformity upon the Tertiary conglomerate is a coarse conglomerate which is believed to be Quaternary in age. Whether it is Pleistocene or Recent has not been ascertained. This younger conglomerate has itself been subjected to diastrophic movements which in one place at least have tilted the strata as much as 22°.

All of the formations discussed above are now being vigorously eroded, while out on the fans and playas alluviation is proceeding at a rapid rate.

Structure—An adequate structural picture of the Tertiary sediments of the Avawatz Mountains locality can be obtained only with detailed mapping. Unfortunately, in the absence of a sufficiently detailed topographical map, such work could not be carried out. In general terms, the dominant structure consists of a series of broadly to closely folded anticlines and synclines. The axes of the folds trend from N. 45° W. to N. 80° W., the former being nearer the mountain front and more nearly in parallel alignment with it. These structures plunge to the east and to the west from a region only a few miles west of the fossil localities.

In the area studied, at least three faults strike approximately east-west and have possibly vertical attitudes. Offset marker beds indicate that the movement along one of these breaks has been of the strike-slip type, the south side having moved eastward relatively to the north side a distance of several thousand feet. Minor faults with offsets of only a few feet are found in abundance throughout the Tertiary sediments. Probably the majority of these are subordinate breaks controlled by the formation of the major structures.

The structure of the Quaternary conglomerate demonstrates two interesting facts: First, in one place, where the conglomerate overlies with angular unconformity the limb of an anticline in the Tertiary rocks, the conglomerate has been tilted so as to dip as much as 22°, but preserves the strike of the underlying, more steeply dipping anticlinal limb. This indicates a continuation of folding along the same axes after a period of quiescence. Secondly, in the relatively undisturbed areas, the Quaternary conglomerate dips away from the main Avawatz range at angles varying from 4° to 8°. The channels of the streams now incising these beds dip at 1.5° or less.

Stratigraphic Column of the Fossiliferous Fluviatile Beds of the Avawatz Formation

Total thickness in feet	Thickness of beds in feet	
	60	Fine to coarse conglomerate resting with angular unconformity upon underlying beds.
976		........................Unconformity........................
	160	Sand layers and pebble conglomerates at base. Pebble lenses are thicker, more frequent in occurrence, and with larger pebbles in upper levels, finally becoming coarse conglomerate.
816		
	4	Punky gray ash.
812		
	76	Brownish-gray alternating coarse and fine fluviatiles, becoming sandy and gravelly toward top.
736		
	3	Punky gray ash. "Marker bed" in structure section.
733		
	150	Soft to hard gray sandy fluviatiles, occasional gravels, and brick-red pebbles. Mastodon 30 feet below "marker."
583		
	6	Punky gray ash, capped by hard sandstone. Highly fossiliferous. Remains of Antilocapridæ, Camelidæ, Equidæ, and Rodentia.
577		
	306	Fluviatiles, mostly greenish-gray sands with few green-gray clays. Some sands are light-gray micaceous arkoses. Fossils first appear here at about 450 feet above base of section.
271		
	64	Sandy fluviatiles, soft to hard, overlying a very thin white volcanic ash.
207		
	29	Greenish-gray punky shale.
178		
	2	Hard white volcanic ash.
176		
	70	Soft, poorly bedded, gray punky clays. Occasional sand layers. One bed of gray ash near base.
106		
	38	Gray ash passing upward into zone of brownish sandstone and gray ash.
68		
	1	Hard brown sandstone.
67		
	34	Light-gray ash, cross-bedded to finely bedded to laminated. Few sandy layers. Occasional layers containing rounded fragments of white volcanic ash.
33		
	27	Greenish-gray clays to gray sands, soft; show no bedding.
6		
	6	Greenish to yellowish-brown sands and gravel beds. Small pebbles of limestone.
0		
		Underlying resistant breccia (atmoclastic breccia), mostly limestone fragments, some gneisses.

Thus strong indication is given that there has been a relatively recent uplift in the area of, and contiguous to, the main body of the Avawatz Mountains.

Later geological history of the Avawatz Mountains—The geological history of the basement complex is a tangled skein which remains to be unraveled. Extremely rapid upwarping or upfaulting of the complex core marked the inception of recorded later geological history of the Avawatz Mountains. Though not strictly datable, this diastrophic movement probably commenced in later Tertiary time, perhaps toward the close of the upper Miocene. During this first uplift, many thousands of feet of very coarse fanglomeratic material were laid down on the flanks of the ancestral Avawatz Mountains. As the uplift slowed and eventually ceased, and as the mountains were eroded down and the intermontane basins were filled, the alluvium undergoing deposition became characteristically finer-grained. At the termination of this stage the topographic relief of the region was considerably reduced and extensive playa lakes lay in the intermontane basins.

Following this period of quiescence came a resurgence of diastrophic activity accompanied by vulcanism. The first swift uplift was marked by deposition of the resistant breccias. Over these breccias, perhaps after a short period of erosion, was laid down the succession of arkoses and tuffs, mostly fluviatile but partly lacustrine, in which were incorporated the scattered remains of many mammals. A gradual coarsening of the sediments, indicative of an increase in relief, brought the record of Tertiary sedimentation to a close in lower Pliocene time.

While all Tertiary diastrophism up to the close of lower Pliocene had been confined to simple successive relative uplifts of the mountain core, the tremendous forces coming into play in the uppermost Tertiary crushed and crumpled, as well as uplifted, the sediments which had been laid down earlier in the period. This Tertiary terrane, now structurally characterized by close folds, strike-slip faults, and perhaps thrust faults, was planed off by erosion to form a fairly even surface with few rugged hills of resistant breccia rising above the general level. On this surface accumulated a conglomerate, perhaps Pleistocene in age, occasionally aggregating several hundred feet in thickness. Renewed movement along old lines of folding locally tilted this conglomerate strongly. The primary dip of this conglomerate away from the mountain mass was considerably steepened by a general upwarping of the central portion of the Avawatz range.

Subsequent to this last uplift, the forces of erosion have been extremely active in dissecting the Tertiary terrane and developing the present youthful topography.

OCCURRENCE AND PRESERVATION OF MATERIAL

Fossil material has been recovered so far only from the uppermost member of the Tertiary Avawatz formation. All of the fossils found in place come from a stratigraphic zone about 250 feet thick immediately underlying the gray tuff marker bed (see fig. 3, also stratigraphic column). Bone fragments are exceedingly common throughout this zone. No complete pieces were found. Though some of the teeth and bones show rounding and water wear, many appear remarkably fresh and unworn. The state of preservation is only fair. Checking has rendered many pieces very difficult

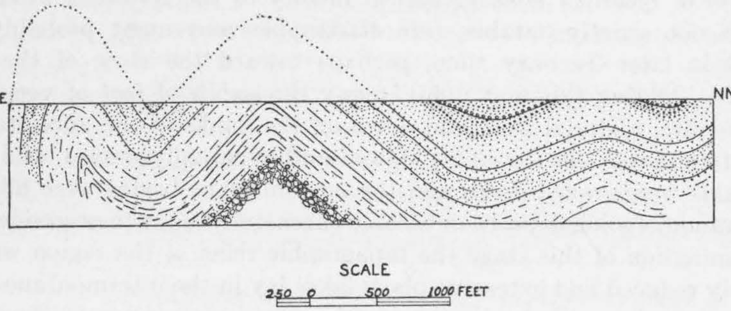

FIG. 3—Diagrammatic section taken at N. 20° W. through the east-west trending folds of the fossiliferous portion of the Avawatz formation. Marker bed indicated by projected dotted line.

to recover and prepare. This condition is believed to have been caused, in part at least, by the stresses set up during diastrophism. Preservation appears to have been brought about under flood-plain conditions, where vertebrate remains were stream-borne or at any rate widely scattered before burial.

ENVIRONMENT OF FAUNA

All the forms known at present to occur in the Avawatz fauna are typical plains dwellers. The vegetation of the region during the period of accumulation must have comprised grass and scrubby trees. Presence of the latter is indicated by occasional finds of petrified wood, the remains of shrub-like growths. To support such vegetation, the climate presumably was somewhat more humid than the present one. Perhaps, as J. C. Merriam suggests in regard to the environmental conditions of the Barstow and Ricardo faunas, the conditions prevailing at the time of existence of the Avawatz fauna resembled those now obtaining in the southern portion of the Great Valley of California.

COMPOSITION AND EVOLUTIONARY STAGE OF FAUNA

The small canid species recorded in the faunal list does not resemble generically any later Tertiary form described in the literature and hence is valueless as an indicator of the age of the fauna.

Presence of *Pseudælurus intrepidus* Leidy, a species based on a well-preserved lower jaw, discovered by Hayden in the sands of the Niobrara River (Leidy 1858, 1869), unfortunately gives no definite indication of age of the Avawatz fauna. Most of the recorded occurrences of *Pseudælurus* are assigned to the Miocene, including Barstow (Merriam 1919), Tonopah

(Stock 1934), Lower Snake Creek (Matthew 1918, 1924), and Niobrara River faunas (Leidy 1869). Two occurrences, however, from the lower Pliocene are referred to *Pseudælurus*, Esmeralda (Stirton 1936) and Valentine (Stirton and McGrew 1935).

An attempt to place the specimens which have been described in the literature in a faunal or evolutionary sequence is unsatisfactory, for some are derived from doubtful horizons while others are not figured, thus making comparisons difficult. A comparison with the Barstow fragment reveals nothing beyond general size agreement. When compared with the small form from Tonopah, the Avawatz specimen appears to be slightly more advanced, as suggested by a less well-developed heel on $M\bar{1}$ and smaller alveolus for $P\bar{2}$. However, these differences may have little significance.

Included in the collection from the Avawatz locality are a number of fragmentary rodent and lagomorph specimens. This assemblage consists chiefly of heteromyid rodents (pocket mice), of which there are present two or possibly three forms. A single specimen of a cricetine, *Peromyscus*, and several individuals of an extinct hare, *Hypolagus*, likewise occur (Wilson 1939).

The material has not afforded definite evidence with regard to age of the assemblage. An upper Miocene or lower Pliocene age is indicated, probably the latter.

In spite of the fact that mastodont remains have been reported from almost all of the Tertiary horizons having assemblages comparable to that of the Avawatz Mountains, only two formations have yielded lower jaw material sufficiently well preserved to be of value in making comparisons. The mastodont recorded as *Trilophodon ?* sp. from the Ricardo (Stock 1928) resembles the Avawatz form, although the mandible on which the former identification is based is very slightly larger than that of the latter in all its measurements. This difference in dimensions falls well within the limits of individual variation. The second occurrence is that of *T. simplicidens*, the type tooth of which was found in the lower Pliocene Bone Valley formation near Pierce, Florida. This horizon is regarded as the equivalent of the Rattlesnake by Simpson (Simpson 1933), while both Rattlesnake and Bone Valley are considered middle Pliocene by Stirton (Stirton 1936). Osborn suggests that the tooth "may be intrusive from older Miocene beds" (Osborn 1936). Since Osborn himself (Osborn 1923; 1936, p. 285) seemed doubtful as to the geologic age of *Trilophodon simplicidens*, a comparison of the Avawatz mastodont with this primitive form does not throw much light on the age of the Avawatz occurrence.

Remains of horses in the Avawatz collection include a poorly preserved upper molar, a set of lower incisors, and a few skeletal fragments, and they furnish little information of value in dating the fauna. The tooth has been assigned to the genus *Pliohippus* on the basis of the extremely strong curvature of crown and of the few features exhibited on the wearing surface. Though *Pliohippus* has been reported from a number of localities which might be referred to the upper Miocene, in general these localities contain mixed faunas representing both upper Miocene and lower Pliocene. The exact stratigraphic position of *Pliohippus* is in doubt in these cases. For the present it is sufficient to say that if *Pliohippus* occurs in a fauna, the chances are excellent that the assemblage falls within the Pliocene. It is regrettable that the advanced stage of wear and poor preservation of the tooth do not permit a more satisfying determination of the relationships of the Avawatz *Pliohippus*.

Two representatives of the Camelidæ are found in the Avawatz fauna. The larger of these is about twice the size of the smaller. Similar variation in size among Tertiary camels appears to be of common occurrence in faunas related in age to the Avawatz. For lack of material, the larger camel cannot be identified, even generically. The smaller form, however, has been referred specifically to *Procamelus coartatus* Stirton, which was described from Fish Lake Valley.

Pending publication by Frick of the stratigraphic and faunal relationships of *Merycodus cerroensis* (Frick) from Round Mountain, New Mexico, the Avawatz antilocaprid has been referred tentatively to Frick's species.

With regard to the position of *Merycodus* cf. *cerroensis* (Frick) in the genus, several definite statements can be made. The material from the Avawatz, like that of Frick's type, represents a specialized form among merycodonts. This is clearly demonstrated by the extreme reduction of the premolar series with respect to the molars and by the remarkable elongation of the post-symphyseal diastema. Frick refers his Round Mountain material to the "Uppermost Late Tertiary," which means presumably at least middle Pliocene. Such a determination might appear logical did we not feel certain that *Ilingoceros* and particularly *Sphenophalos* had established themselves by that time as the dominant antilocaprids (Merriam, Stock, and Moody 1925). Furthermore, the merycodont tentatively referred to *M. cerroensis* may be an unusually advanced type, in this regard standing in contrast to the more primitive aspect of the remainder of the fauna. With the discovery of more material in the Ricardo such an assumption may prove unnecessary, for in at least one Ricardo specimen (U.C. No. 22450, Merriam 1919, fig. 243), in which molars and premolars are preserved in the same ramal fragment, there exists a strong suggestion of premolar reduction comparable to that found in *M.* cf. *cerroensis* from the Avawatz and in *M. cerroensis* from Round Mountain, New Mexico. Hence, though the structure of the horn core remains distinct, the dentary of the Ricardo *Merycodus* with its slightly more hypsodont molars and slightly less reduced premolars may, in stage of development, be roughly analogous to the Avawatz form.

RELATIONSHIPS OF FAUNA

Great Basin—In the Tertiary deposits of the Great Basin region of southeastern California and western Nevada occur several faunas whose constituencies resemble that of the Avawatz. However, greatest resemblance appears to exist between the latter and assemblages that are either latest Miocene or earliest Pliocene in age. In the Barstow fauna (Merriam 1919) no forms are similar to those found in the Avawatz. *Merycodus necatus* Leidy from the Barstow exhibits characters which are decidedly more primitive than those of *M.* cf. *cerroensis* (Frick). Greater similarity, on the other hand, exists between the faunas from the Avawatz and Ricardo deposit (Merriam 1919, Matthew 1924, Stock and Furlong 1926, Matthew and Stirton 1930, Stirton and Vander Hoof 1933). *Trilophodon* cf. *simplicidens* Osborn appears to be close to *Trilophodon ?*, sp. (Stock 1928). *Pliohippus ?*, sp. may be related to one of the Ricardo pliohippines. *Procamelus coartatus* from the Avawatz approaches the form *Procamelus*, sp. b described by Merriam from the Ricardo. The merycodonts, although not of the same species, represent approximately a similar stage of advancement. *Pseudælurus ?* occurs in the Fish Lake Valley fauna (Stirton 1929, 1932, 1936), but for lack of adequate material this species cannot be compared directly with that of the Avawatz. *Pliohippus* cf. *leidyanus* and *Procamelus coartatus* occurring in the Fish Lake Valley fauna may well have been contemporaries of the Avawatz forms.

Pacific Coast—Tertiary assemblages from the Pacific Coast Province do not offer any close comparisons with the Avawatz fauna. The Chanac fauna which has been described in the literature (Merriam 1916*b*, Hoots 1930, Stock 1935) is very incompletely known except for the Equidæ. Some undescribed material in the collections of the California Institute of Technology indicates that although the Antilocapridæ from the Chanac are probably less advanced than those of the Avawatz, the Proboscidea and Equidæ may be more advanced. The Orinda-Siesta fauna (Merriam 1913, 1917, Stock 1921, Stirton 1935), for lack of corresponding material, cannot be compared with the Avawatz. The fauna from Mint Canyon (Maxson 1930, Stirton 1933) may represent more than one stage, while that from the Cuyama (Gazin 1930) does not furnish an adequate basis for comparison.

Great Plains—In the Great Plains Province there are again several mixed faunas with which comparison is at present difficult, if not meaningless. The Santa Fe of New Mexico certainly represents more than one faunal stage (Frick 1933, p. 549), and this is true also for the Upper Snake Creek of Nebraska. The fauna formerly termed Valentine has been divided into three parts by Stirton and McGrew (1935). The middle of these, the Burge, is characterized by an assemblage which may approximate in time that from the Avawatz. In the latest available list of mammals from the Burge (McGrew and Meade 1938), the comparable forms have been determined generically but not specifically; hence critical comparison is not yet possible. The Madison Valley fauna of Montana (Douglass 1900) appears definitely more primitive than the Avawatz. The Clarendon fauna of Texas (Cope 1893) contains no forms comparable to those from the California locality.

FAUNAL LISTS

Ricardo	Avawatz	Fish Lake Valley	Barstow
		Insectivora	
		Meterix latidens Hall	
		Metechinus nevadensis Matthew	
		Chiroptera	
		Mystipterus vespertilio Hall	
Carnivora	Carnivora	Carnivora	Carnivora
Canid, small near Canis ? vafer Leidy	Canid, indet.		Canid (Canis ?), sp. small
Ælurodon ? aphobus Merriam		Ælurodon haydeni (Leidy)	Tephrocyon, near temerarius (Leidy)
Ælurodon ?, n. sp. a			Ælurodon, near wheelerianus Cope
Ælurodon ?, n. sp. b			Ælurodon, Dinocyon, or Amphicyon, sp.
Ælurodon or Tephrocyon, sp. c			
Ælurodon or Tephrocyon, sp. d			
Osteoborus ricardoensis Stirton and Vander Hoof			
Hadrocyon mohavensis Stock and Furlong			Machærodont, sp. a
Mustela ? buwaldi Merriam			Machærodont, sp. b
Ischyrosmilus osborni Merriam			Machærodont, sp. c
Felid, large			Felid ?, indet.
Felid, small, not Ischyrosmilus	Pseudælurus intrepidus Leidy	Pseudælurus ?	Pseudælurus, sp.
Rodentia	Rodentia	Rodentia	Rodentia
		Eucastor tortus Leidy	
		Mylagaulus, sp.	
		Entoptychus ?	
	Perognathoides cf. tertius (Hall)	Perognathoides quartus (Hall)	
	Perognathoides ?, sp. undet.	Perognathoides tertius (Hall)	
	Dipodomyine ?, n. g. et sp.	Macrognathomys nanus Hall	
	Peromyscus dentalis Hall	Peromyscus dentalis Hall	
Lagomorpha	Lagomorpha	Lagomorpha	Lagomorpha
Lepus ?, sp.	Hypolagus, sp.	Hypolagus cf. vetus L. Kellogg	Lepus ?, sp.
		Sylvilagus ?	
Proboscidea	Proboscidea	Proboscidea	Proboscidea
Trilophodon ?, sp.	Trilophodon cf. simplicidens Osborn		
Tetrabelodon ?, sp.			Tetrabelodon ?, sp.

(Continued on next page)

FAUNAL LISTS—*Continued*

Ricardo	Avawatz	Fish Lake Valley	Barstow
Perissodactyla	Perissodactyla	Perissodactyla	Perissodactyla
Aphelops, sp.			
Peraceras ?, sp.			
Hipparion mohavense Merriam		Hypohippus, near nevadensis Merriam	Hypohippus, near affinis (Leidy)
Hipparion mohavense callodonte Merriam		Neohipparion cf. occidentale Leidy	Parahippus ? mourningi Merriam
Hipparion, sp. a			Merychippus (Protohippus) intermontanus Merriam
Hipparion, sp. b		Pliohippus cf. leidyanus Osborn	Merychippus calamarius stylodontus Merriam
Pliohippus tantalus Merriam	Pliohippus ?, sp.		Merychippus sumani Merriam
Pliohippus fairbanksi Merriam			Protohippus ? or Pliohippus ?, sp.
Pliohippus, sp. near mirabilis (Leidy)			
Artiodactyla	Artiodactyla	Artiodactyla	Artiodactyla
		Tayassuidæ	Tayassuidæ
		Prosthennops cf. crassigenis Gidley	Prosthennops ?, sp.
Merycoidodontidæ			Merycoidodontidæ
Metoredon californicus (Merriam)			Merycochœrus buwaldi Merriam
Camelidæ	Camelidæ	Camelidæ	Camelidæ
Procamelus, sp. a		Procamelus gracilis Leidy	Procamelus, sp. a
Procamelus, sp. b	Procamelus coartatus Stirton	Procamelus coartatus Stirton	Procamelus, sp. b
Pliauchenia, sp.	Camelid, sp. large	Procamelus cf. robustus Leidy	Pliauchenia, sp.
Alticamelus ?, sp.		Alticamelus cf. priscus Matthew	Alticamelus ?, sp.
			Cervidæ
			Dromomeryx or Cervus ?, sp.
Antilocapridæ	Antilocapridæ	Antilocapridæ	Antilocapridæ
Merycodus, near necatus Leidy	Merycodus cf. cerroensis (Frick)	cf. Merycodus	Ramoceras (Paramoceras) brevicornis Frick
Merycodus furlongi (Frick)			Ramoceras (Merriamoceras) coronatus (Merriam)
			Merycodus (Paracosoryx) alticornis (Frick)
			Meryceros joraki Frick

Conclusion—Although the fragmentary nature of the material and an almost complete absence of equine remains make anything more than a suggestion of chronologic arrangement impossible, all available evidence points to a position of the Avawatz fauna in time close to that of the Ricardo and Fish Lake Valley. The Avawatz is perhaps slightly pre-Ricardo in age and approximately the equivalent of the Fish Lake Valley.

RELATIONSHIP OF THE AVAWATZ FAUNA TO MIOCENE-PLIOCENE VERTEBRATE HORIZONS OF WESTERN NORTH AMERICA

Age	California		Nevada	Oregon	Nebraska
	Pacific Coast	Mohave			
Middle Pliocene			Thousand Creek	Rattlesnake	
Lower Pliocene	Chanac	Ricardo Avawatz	Fish Lake Valley		Burge
Upper Miocene		Barstow			Valentine

DESCRIPTION OF FAUNA

CARNIVORA

CANIDÆ

Canid, indet.

A right maxillary fragment (C.I.T. No. 2308, plate 2, figs. 2 and 2*a*) possessing the premolar tooth-row but lacking the molars, canine, and incisors, belongs to a canid species approximating the fox (*Vulpes*) in size.

P$\underline{1}$ is a peg-like, single-rooted tooth with rounded anterior ridge, convex in profile. The ridge running from apex to posterior border, on the other hand, is more sharply defined and has a concave profile. Near the cingulum this concavity is more pronounced, so that a slight but definite shelf is formed. Hence, an angular break in tooth profile occurs between the posterior edge of the crown and the posterior edge of the root of the tooth.

P$\underline{2}$ is slightly injured anteriorly. This tooth is double-rooted and presents a triangular lateral aspect. The anterior ridge is almost straight from tip to border of crown, while the posterior border is concave.

P$\underline{3}$ is considerably larger than P$\underline{2}$ and possesses a slightly concave anterior ridge and a strongly concave posterior ridge. No extra tubercles or cusps subsidiary to the main cusp are present.

In P$\underline{4}$ the principal cusp is the acutely pointed paracone, while the metacone forms a long shearing blade. A small well-developed protocone is present, but the position of this cusp is not so far anterior as in other canids. The tooth further differs from that of other canids in being larger, more robust, and not so compressed laterally. The blade-like edges are not so sharp and the interconal notches not so deep in No. 2308 as in P$\underline{4}$ of Recent canids.

Relationships—The form and proportions of the specimen from the Avawatz resemble fairly closely those of *Vulpes vafer* (Leidy). However, in the literature the upper dentition of this species is neither discussed nor figured. Hence, it seems undesirable to refer the form to the species *V. vafer*.

Since all the teeth of the premolar series in No. 2308 show distinctive differences from corresponding teeth in *Vulpes macrotis*, it is probably safe to say that the two forms do not belong to the same genus.

Measurements (in millimeters)

	No. 2308 C.I.T.
P$\underline{1}$–P$\underline{4}$, total length	32.5
P$\underline{1}$, anteroposterior diameter	3.2
P$\underline{1}$, transverse diameter	2.0
P$\underline{2}$, anteroposterior diameter	ca. 5.7
P$\underline{2}$, transverse diameter	2.0
P$\underline{3}$, anteroposterior diameter	6.5
P$\underline{3}$, transverse diameter	2.3
P$\underline{4}$, anteroposterior diameter	11.0
P$\underline{4}$, transverse diameter	5.0

FELIDÆ

Pseudælurus intrepidus Leidy

A poorly preserved left ramus is the only diagnostic felid material from the Avawatz (C.I.T. No. 2309, plate 2, figs. 1 and 1*a*). The lower edge and posterior portion of the ramus are missing. P$\bar{3}$, P$\bar{4}$, and M$\bar{1}$ remain, but are badly shattered. A small calcaneum and astragalus in the collection are perhaps of this species.

In size the ramus resembles *Pseudælurus intrepidus* Leidy (1869) much more closely than it does the smaller form *Pseudælurus marshi* Thorpe (1922). The anterior mental foramen is large and lies below P$\bar{2}$. Behind this opening are two small foramina, which lie beneath the posterior root of P$\bar{3}$. The masseteric fossa is deep, with anterior end reaching forward to a point beneath the posterior root of M$\bar{1}$.

The incisors are lacking. The canine is likewise gone, but judging from that portion of its alveolus which remains this tooth was of large size. Behind a short diastema, there appears to be a small cup-like depression on the alveolar border of the ramus which may represent a socket for a small single-rooted P$\bar{2}$.

P$\bar{3}$ is a large double-rooted tooth. The crown consists of a large central cusp with small anterior and posterior cuspules. Of these, the anterior is the least developed. This tooth, along with those which follow, is set slightly diagonally to the fore-and-aft axis of the jaw.

P$\bar{4}$ is so placed that its anterior end lies immediately inside the posterior end of P$\bar{3}$, and the teeth overlap about 2 mm. It is slightly larger than P$\bar{3}$, double-rooted, and with anterior and posterior cusps larger in proportion to the main cusp than are those of P$\bar{3}$. Posteriorly there is, in addition, a fourth very low heel-like cusp, the talonid.

M$\bar{1}$ overlaps P$\bar{4}$ on the inside by more than 3 mm. and has a position decidedly diagonal with reference to the long axis of the ramus. The acutely pointed paraconid is separated by a broad deep notch from the protoconid or main cusp. A very small cusp on the posterior ridge of the tooth is all that is left of the metaconid. The talonid or heel, while not so much reduced as the metaconid, is weakly developed. There is no indication of a second molar.

Relationships—In structural characters the species from the Avawatz Mountains resembles most closely Leidy's *Pseudælurus intrepidus*. The differences between the Californian form and the type of *P. intrepidus* are the relatively advanced position of the anterior edge of the masseteric fossa in the former and the relatively greater diastema between C̄ and P$\bar{3}$ in the latter.

Age—Most of the recorded occurrences of *Pseudælurus* are assigned to the Miocene, including those from Barstow, Tonopah, and Lower Snake

Comparative measurements (in millimeters)

	Pseudælurus intrepidus Avawatz No. 2309 C.I.T.	Niobrara	Tonopah No. 772 C.I.T.	Tonopah No. 1233 C.I.T.	Tonopah No. 1234 C.I.T.	*P. marshi* Thorpe Valentine No. 12865 Y.P.M.
Depth of jaw at posterior end of M$\bar{1}$	ca. 22.5	22.5	ca. 21.7	22.5		21.7
Thickness of jaw below M$\bar{1}$	11.0		9.5	9.5		
P$\bar{3}$–M$\bar{1}$, total length	42.7	43.6	42.5	38.2		36.0
Diastema between C̄ and P$\bar{3}$	10.0	14.8		10.0		8.6
P$\bar{3}$, anteroposterior diameter	11.0	11.4	10.5	10.3		9.5
P$\bar{3}$, transverse diameter	5.0	5.2	5.3	4.6		4.8
P$\bar{4}$, anteroposterior diameter	15.5	14.8	14.3	13.0	12.5	12.5
P$\bar{4}$, transverse diameter	6.6	7.2	6.8	5.8	6.0	6.0
M$\bar{1}$, anteroposterior diameter	19.6	19.6	ca. 18.9	15.3	16.5	16.0
M$\bar{1}$, transverse diameter	ca. 7.8	7.9	ca. 7.0	6.6	6.9	7.5

Creek. The genotype described by Gervais came from Sansan (Miocene). Leidy, however, records *Pseudælurus* from his Bed F or Pliocene and upward. Nevertheless, the occurrence of *Pseudælurus* in the Avawatz fauna suggests a Miocene rather than a Pliocene age.

PROBOSCIDEA

Trilophodon cf. simplicidens Osborn

An incomplete and badly fractured mandible (C.I.T. No. 1984, plate 2, fig. 3) bearing three poorly preserved molar teeth (right $M\overline{2}$ and $M\overline{3}$; left $M\overline{2}$) represents available proboscidean material from the Avawatz Mountains. Although the posterior portion of the symphysis remains, the anterior end is lacking. The preserved portion of the symphyseal area suggests considerable elongation and slight downward deflection of the mandible in this region. The right ramus extends posteriorly only to the heel of $M\overline{3}$ and the left ramus is broken or eroded off at the middle of $M\overline{3}$. Enamel thickness measures approximately 7 mm.

Both second lower molars show considerable wear. They retain enough of their original form, however, to demonstrate the fundamental pattern of three main ridge crests. Unfortunately the state of wear has removed all evidence of the presence or absence of central conules in a younger stage.

In the right $M\overline{3}$ the internal cone of the tetartolophid and the entire heel are missing. All of the main cones are broken off in the anterior portion of this tooth. The ridge crest formula was probably 4½. Intercrestal conules are present and it is doubtful whether these would develop a trefoil pattern with further wear. The tooth as a whole is very slender and possesses a low breadth-length ratio.

The specimen is distinctive by reason of its small size and simplicity of dental pattern. These characters are apparent in but one of all the American trilophodonts, namely *Trilophodon simplicidens* Osborn (1923, 1936) from the lower Pliocene Bone Valley of Florida. The Avawatz form resembles in appearance, but is slightly smaller than, the specimen from the Ricardo referred by Stock to *Trilophodon* (?), sp. (Stock 1928).

Comparative measurements (in millimeters)

	T. cf. *simplicidens* Avawatz No. 1984 C.I.T. (approximate only)	*T. simplicidens* Bone Valley No. 1907 Amer. Mus.
Transverse diameter across protolophid	53	
Transverse diameter across metalophid	57	60
Transverse diameter across tritolophid	58	63
Transverse diameter across tetartolophid		55
Height of tetartolophid	37	35

PERISSODACTYLA

EQUIDÆ

Horses are conspicuous because of their scant representation in the Avawatz fauna. Among the fragments found are a set of lower incisors and canines (C.I.T. No. 2313, plate 2, fig. 4) and a distal end of a tibia for which no definite generic determination seems possible. A much worn upper cheek-tooth is described below (C.I.T. No. 2312, plate 2, fig. 5).

Pliohippus ?, sp.

The tooth appears to be a first molar. The plications in an otherwise simple crown-pattern are a pli protoconule and a pli caballin. The fossettes appear simple and large. The large, flattened-oval protocone, though only partially preserved, is obviously united to the protoloph. Strong curvature characterizes the worn crown. The size and curvature of the crown as well as the simple type of enamel pattern are strongly suggestive of the genus *Pliohippus*.

Measurements (in millimeters)

$M\underline{1}$, anteroposterior diameter	24.5
$M\underline{1}$, transverse diameter	ca. 23.0
$M\underline{1}$, crown height (measured along mesostyle)	33.4

ARTIODACTYLA

CAMELIDÆ

Camelid remains occur in abundance but, unfortunately, most of the material is so fragmentary as to be of little diagnostic value. The collection includes fossil camelid remains which fall into two distinct size groups.

Procamelus coartatus Stirton

The material referred to this species belongs to several individuals. At any rate, no two fragments can be assigned to a single individual with any degree of certainty. The material consists of a fairly well-preserved palate of an adult, containing the tooth-row complete from $P\underline{2}$ to $M\underline{3}$ (C.I.T. No. 1989); a partially preserved palate of a young specimen bearing $Dm\underline{3}$, $Dm\underline{4}$, and $M\underline{1}$ (C.I.T. No. 2315); several ramal fragments, none of which carries the complete mandibular dentition; lower teeth including $P\overline{2}$ (roots only), $P\overline{3}$, $P\overline{4}$, $M\overline{1}$, $M\overline{2}$, $M\overline{3}$, and $Dm\overline{4}$; several ramal symphyses; distal end of humerus; proximal end of radius and distal end of radius-ulna; proximal and distal ends of femur; distal end of tibia; distal end of a cannon bone; termini of a proximal phalanx; two median phalanges.

Although the material from the Avawatz averages about one-tenth smaller in every dimension, in all other respects it approximates closely Stirton's type specimen from the Fish Lake Valley beds, Nevada (Stirton 1929).

Stirton states[1] that specimen U.C. No. 29612, provisionally assigned by him to *Procamelus gracilis* Leidy, may also be referable to the species *P. coartatus*. The difficulty in arriving at a definite determination lies in the fact that, in making a restoration of the palate, the proper width of the roof of the mouth between the second upper premolars cannot be ascertained with accuracy. If in the restoration the anterior portions of the maxillaries were brought somewhat closer together, the palate would appear remarkably similar to that of the typical *P. coartatus*. In the following comparison this specimen (U.C. No. 29612) will be regarded as of the species *P. coartatus*.

The palate from the Avawatz (C.I.T. No. 1989, plate 3, fig. 1) bears a marked resemblance to that in the University of California collections from Fish Lake Valley (U.C. No. 29608). Especially striking is the extreme constriction of the palate just anterior to $P\underline{2}$ in both specimens. No other species of the genus *Procamelus* exhibits such extreme "pinching in" of the

[1] Personal communication.

anterior portion of the palate. A palatine foramen lies median to the posterior lobe of M$\underline{1}$.

The well-worn upper premolar teeth of the Avawatz form seem to be of proportions similar to those of specimens U.C. No. 29608 and U.C. No. 29612, although in the case of the latter the teeth appear to be slightly narrower in relation to their length. Part if not all of the relatively great breadth which is so striking in the illustrations of C.I.T. No. 1989 may be ascribed to an advanced stage of wear of the molar series.

In M$\underline{1}$ of U.C. No. 29612 there is present a very prominent accessory lingual cusp. M$\underline{1}$ of C.I.T. No. 1989 has been worn down to such an extent that if a comparable cusp ever was present it has now been entirely obliterated. However, in a maxillary fragment (C.I.T. No. 2341) in the Avawatz collection an unworn M$\underline{1}$ does not possess an accessory lingual cusp. The significance of this cusp in the U.C. specimen is uncertain.

Knowledge of the lower dentition of the species from the Avawatz must be obtained from fragmentary evidence. No evidence is available concerning the general proportions of the ramus. Individual teeth or short series of teeth on scattered mandibular fragments furnish some information on the lower dentition.

One fragment bears very well-worn teeth, P$\overline{2}$ (roots only), P$\overline{3}$, P$\overline{4}$, M$\overline{1}$, and M$\overline{2}$ (badly shattered roots only) (C.I.T. No. 2316, plate 3, fig. 2). Another fragment carries M$\overline{2}$ (moderately worn) (C.I.T. No. 2317, plate 3, fig. 5), while M$\overline{2}$ and M$\overline{3}$ (well worn) are present on a third fragment (C.I.T. No. 2318, plate 3, fig. 3). Dm$\overline{4}$, well preserved and only moderately worn, occurs in another fragment (C.I.T. No. 2319, plate 3, fig. 4). This tooth is almost identical with a long narrow Dm$\overline{4}$ from the Ricardo (Merriam 1919, fig. 219).

Because of difference in stage of wear, the dental patterns of the lower teeth in the collections of the California Institute cannot be compared critically with those occurring in U.C. No. 19820 from the Cedar Mountain beds of Stewart Valley. In general, however, they appear to be accordant. The material from the Avawatz is not so large and robust. The premolars of the Avawatz form appear to be somewhat reduced, but perhaps much of this apparent reduction is to be ascribed to the advanced stage of wear which these teeth display.

Although the mandibular symphyses in the collection show some variation in size, they are all characterized by a strong constriction of the lower side of the symphysis slightly anterior to the mental foramen. The halves of the mandible in an adult individual are firmly fused along the symphyseal plane, leaving no trace of suture. One specimen bears the shattered roots of three incisors, one canine immediately posterior to the incisors, and P$\overline{1}$, double-rooted, located directly above the mental foramen (C.I.T. No. 2320). In another specimen of a young individual the symphyseal suture is not yet obliterated. In this fragment the canines are small and P$\overline{1}$ has not yet erupted (C.I.T. No. 2321, plate 4, fig. 3).

With minor variations the limb bones of *P. coartatus* from the Avawatz fall within the limits of individual variation of the Recent *Lama huanachus* (see plate 4).

Comparative measurements (in millimeters)

Palate:	Avawatz No. 1989 C.I.T.	Fish Lake Valley No. 29608 U.C.
Inside width at narrowest point (measured on crests of alveolar ridge)	7	8
Distance between inner edges of fourth premolars	22	ca. 29

Upper dentition:	Avawatz C.I.T. No. 1989	Fish Lake Valley U.C. No. 29608	Fish Lake Valley U.C. No. 29612
P$\underline{2}$–M$\underline{3}$, total length	95.8		106.8
P$\underline{2}$, anteroposterior diameter	8.0	8.7	8.7
P$\underline{2}$, transverse diameter	5.0	4.5	4.5
P$\underline{3}$, anteroposterior diameter	11.2	12.4	11.8
P$\underline{3}$, transverse diameter	6.8	6.6	6.0
P$\underline{4}$, anteroposterior diameter	11.4	11.5	12.0
P$\underline{4}$, transverse diameter	9.4	9.7	9.0
M$\underline{1}$, anteroposterior diameter	15.3 (base)	21.0 (crown)	17.2 (base) 21.6 (crown)
M$\underline{1}$, transverse diameter	15.5 (base)	14.2 (crown)	16.9 (base) 14.9 (crown)
M$\underline{2}$, anteroposterior diameter	25.2	24 ?	28.4
M$\underline{2}$, transverse diameter	17.8	19 ?	16.4
M$\underline{2}$, crown height	12.0 (worn)		28.0 (unworn)
M$\underline{3}$, anteroposterior diameter	29.8		27.8
M$\underline{3}$, transverse diameter	17.7		16.4
M$\underline{3}$, crown height	16.0 (worn)		21.0 (unworn)

Mandible:	Avawatz No. 2321 C.I.T.	Fish Lake Valley No. 19820 U.C.
Narrowest width of symphysis	20.0	30.4
Height of symphysis at narrowest width	15.8	27.2
Lower dentition:	No. 2316	
P$\bar{2}$–M$\bar{1}$, total length	40.0	46.9
P$\bar{2}$, anteroposterior diameter	5.2 base	6.0 base
P$\bar{2}$, transverse diameter	2.8	3.6
P$\bar{3}$, anteroposterior diameter	8.4	11.0
P$\bar{3}$, transverse diameter	4.4	5.0
P$\bar{4}$, anteroposterior diameter	11.2	13.9
P$\bar{4}$, transverse diameter	5.5	6.4
M$\bar{1}$, anteroposterior diameter	15.4	15.8
M$\bar{1}$, transverse diameter	10.2	10.6
	No. 2317	
M$\bar{2}$, anteroposterior diameter	22.5 base	22.0 base
M$\bar{2}$, transverse diameter of anterior lobe	11.0	12.5
M$\bar{2}$, transverse diameter of posterior lobe	13.8	16.8
	No. 2318	
M$\bar{3}$, anteroposterior diameter	34.0	40.0 base
M$\bar{3}$, transverse diameter	?	
	No. 2319	
Dm$\bar{4}$, anteroposterior diameter	25.5	
Dm$\bar{4}$, transverse diameter of anterior lobe	5.7	
Dm$\bar{4}$, transverse diameter of posterior lobe	7.2	
Dm$\bar{4}$, transverse diameter of medial lobe	6.8	

Camelid, indet.

A portion of a large mandibular symphysis, many vertebræ, the iliac portion of an innominate bone, distal end of a tibia (C.I.T. No. 2336, plate 4, fig. 7), an astragalus (L.A. Mus. Coll.), distal end of a metapodial, one complete (C.I.T. No. 2340, plate 4, fig. 8) and one incomplete proximal phalanx indicate the presence of a large camelid almost exactly twice the size (linear) of *P. coartatus*. The fragmentary state of this material and the fact that the material has little diagnostic value preclude the possibility of making a satisfactory generic determination.

ANTILOCAPRIDÆ

Merycodus cf. cerroensis (Frick)

Merycodont remains are the most abundant fossil specimens found in the Tertiary beds of the Avawatz Mountains. While fragments of horn cores, parts of rami, and loose teeth abound, complete and well-preserved specimens are rare. Small bones and terminations of larger elements of the appendicular skeleton are well represented in the collection. However, one of the long limb bones was preserved intact. That some of the individuals are quite young is attested to by the several rami which bear the deciduous fourth premolar and by the terminal epiphyses of the phalanges that are often free from the main shafts. The unworn state of the crowns of teeth indicates that none of the rami or maxillæ belonged to individuals older than young adults. In no case was a dental series found in definite association with horn cores. Like the teeth and phalanges, however, the horn cores probably represent mostly sub-mature to young adult individuals.

Typical specimens of horn cores have a long beam which branches into two tines of subequal length and longer than the beam. There is a tendency to form a wide flare where the tines branch off, and the latter tend to bend inward at the tips (C.I.T. Nos. 1992, 1994, 1993, and 1991, plate 5, figs. *a*, *b*, *c*, and *d*; also C.I.T. No. 1990, plate 6, figs. 1 and 1*a*). The base of each horn core stands directly over the posterior portion of the orbit. The pedicle of the core rises perpendicularly on the frontlet, but it curves anteriorly and laterally toward the region of bifurcation. The two tines diverge at approximately 90°; one is directed anteriorly while the other projects laterally. In both tines a reverse curve occurs in the last 45 mm., so that the tips point upward. The anterior tine (120 mm.) is slightly longer than the lateral tine (110 mm.). When the part of the frontlet between and posterior to the horn cores is held horizontally, a plane passed through the lower part of a pair of tines makes an angle of less than 45° with the horizontal. Also such a plane lies at an angle of approximately 60° to the median plane of symmetry of the skull. This latter figure is especially significant in that no specimens yet described show such a high degree of rotation of the tines from the usual fore-and-aft position. The surface of the horn core is grooved by shallow anastomosing nutrient canals. All parts of the horn core, except in the proximity of the spread-out bifurcation, are round-oval to circular in cross-section.

Of the horn cores figured in the literature, the specimens at hand resemble most closely those from Ricardo and Barstow, California, identified only generically as *Merycodus* sp. (Furlong 1927, plate 28, U.C. Nos. 27242, 27243, and 27249). Other figures which bear marked similarity in structure and proportions to the horn-core material from the Avawatz Mountains are those of *Cosoryx* (*Subcosoryx*) *cerroensis* Frick from Round Mountain Quarry, New Mexico (Frick 1937, fig. 38, F:A.M. Nos. 33105, 33108, 33113H, 33114, 33116). This species is characterized by Frick (Frick 1937, pp. 336 and 338) as having a variable prong-to-beam ratio, but always "with tendency to rather wide flare and bending of tips." Also, "several cranial saddles indicate the presence of individuals in which the horn-cores are peculiarly rotated antero-inwardly." A horn core from the Cedar Mountain beds of Ione Valley, Nevada, identified by Merriam as *Merycodus furcatus* (Leidy) also exhibits the form of the specimens from the Avawatz Mountains (Merriam 1916*a*, fig. 44, U.C. No. 21492).

Other horn cores described in the literature and identified as *M. necatus* or *M. furcatus* are not proportioned and curved as are the specimens from the Avawatz.

Only one beam out of the twenty in the collection appears to be without a burr. It is significant that while all other cores are relatively robust, having maximum diameters from 17 to 21 mm. below the burr, the burrless beam is delicate and has a maximum diameter of only 13.5 mm. The latter unquestionably belonged to a young individual. Most of the burrs slope more or less steeply downward from a high anterior to a low posterior position.

In only one specimen is a frontlet preserved. The loosely knit sutures point to the youth of this individual. The frontoparietal suture crosses the skull rather far back (10.4 mm.) behind a line drawn tangent to the posterior side of the horn cores. This is not so far back, however, as in some skulls of *Merycodus* from other localities. The width measured between the lateral sides of the horn cores is 63 mm., while the width between the medial sides is only 32 mm. The frontals dome up between the horn cores along the median line of the skull. Immediately anterior to this doming the frontals drop away sharply to form a shallow depression. The supraorbital foramina are situated in deep hollows, anterointernal to the bases of the horn cores. Although no orbits have been completely preserved, they appear to be characteristically large and strongly projecting.

Besides numerous loose teeth, three or four fragmentary maxillary dentitions and more than a dozen parts of rami have been preserved. A single right maxilla and a single left ramus are the only specimens which bear complete tooth-rows.

Of the upper molars, M$\underline{2}$ and M$\underline{3}$ are clearly long-crowned teeth. M$\underline{1}$ still retains roots which are approximately one-third the length from root-tip to wearing surface. P$\underline{3}$ and P$\underline{4}$ are definitely hypsodont, but by no means so long-crowned as are the corresponding teeth in *Antilocapra americana*. P$\underline{2}$ shows only slight tendency toward hypsodonty.

Present among the Avawatz material is a portion of a maxillary tooth-row containing Dm$\underline{4}$, M$\underline{1}$, and a partially erupted M$\underline{2}$ (C.I.T. No. 1996). Dm$\underline{4}$, which has not yet been figured or described in the literature, is a short-crowned tooth with two-lobed crown-pattern, in contrast to the single crescent form of P$\underline{4}$. The posterior lobe of Dm$\underline{4}$ resembles a molar crescentic lobe, but is slightly more compressed anteroposteriorly and does not have such prominent styles as are found in a molar. The anterior lobe is asymmetric. Its crescentic pillar is strongly developed and a deep valley, reaching to the cingulum, lies between this crescentic pillar and the anterior very weak parastyle. This arrangement of a weak parastyle, a strong anterior crescentic pillar, and a still stronger posterior lobe gives the buccal surface of the tooth crown a step-like appearance.

The ratio of length of premolar tooth-row to length of molar tooth-row indicates an amount of shortening of the premolar series greater than that found in most merycodonts. Furthermore, the entire tooth-row appears to be more compressed laterally than is common in other merycodonts. Except for this general lateral compression, the crown-pattern of the upper dentition is in complete harmony with the pattern observed in all merycodonts and antilocaprids (Frick's *Antilocapridæ*). On the external side the crescentic pillars are merely gently rounded ridges. The styles, in contrast, are sharply marked ridges.

The lack of depth in the horizontal ramus is rather striking, but certainly of no specific value, for several forms possess jaws just as shallow, notably

Merycodus necatus sabulonis Matthew and Cook (1909, A.M. No. 14109), and *Cosoryx* (*Subcosoryx*) *cerroensis* Frick (F:A.M. Nos. 32938, 30982, 31996). A feature of greater significance is the length of the diastema between mandibular symphysis and $P\overline{2}$. In Frick's table VIII of "Comparative Measurements and Ratios of Merycodontini Mandibles" (Frick 1937, pp. 384–390) no form except *C.* (*Subcosoryx*) *cerroensis* shows a post-symphyseal diastema so great in comparison with the longitudinal diameter of $M\overline{3}$.

$M\overline{2}$ and $M\overline{3}$ have reached an advanced stage of hypsodonty. $M\overline{1}$ is less hypsodont, while the premolars retain rather short crowns. In general, the cheek-teeth might be said to exhibit a slightly more advanced stage of hypsodonty than that displayed in many, if not in most, of those figured by Frick. The Avawatz teeth are considerably more hypsodont than those from the Barstow, and slightly less so than those from the Ricardo as illustrated by Merriam and by Frick. The shortening of the premolar tooth-row, in comparison with the length of the molar tooth-row, is even more striking in the lower series than in the upper dentition. This shortening, which is rivaled only by the extreme case found in *C.* (*Subcosoryx*) *cerroensis* Frick (see tables of measurements, Frick 1937, pp. 384–390), may be of specific value. Lateral compression, especially in the premolars, is pronounced. Frick states that the species *C.* (*Subcosoryx*) *cerroensis* is "characterized by reduction of the premolars, particularly $P\overline{2}$ and $P\overline{3}$, and elongation and slenderness of the diastema" (Frick 1937, p. 392).

The crown-pattern of the lower dentition follows closely the merycodont-antilocaprid pattern. The molars have a strongly developed anterior parastylid which forms a very sharp ridge extending from the crown almost to the base of the tooth. The third lobe in $M\overline{3}$ is strongly developed, with a triangular to egg-shaped crown-pattern, slightly flattened on the interior side, and having the larger end posterior. The crown-pattern of the premolars is very simple, consisting of only three internal ribs separated by open valleys which do not reach down to the cingulum. On the external side of the premolars, immediately posterior to the median transverse crest, lies a broad but pronounced depression extending from cingulum to crown. The anteroexternal side of the typical premolar is rounded and convex. Since considerable variation may occur in the crown-pattern of $P\overline{4}$, that pattern may be of specific value. In all Avawatz specimens it consists of three simple transverse crests.

Several mandibles in which $M\overline{2}$ is erupting still retain the $Dm\overline{4}$. This milk tooth is short-crowned and consists of three major lobes with simple molariform crown-pattern. Of these crescentic lobes the anterior is the smallest, being about one-half the size of the posterior lobes.

The material representing the appendicular skeleton is fragmentary. Various phalangeal elements and extremities of the longer limb bones resemble closely the corresponding parts in *Antilocapra americana*. Measurements indicate that the form from the Avawatz is slightly larger than *Merycodus osborni* from Pawnee Creek, Nebraska (Matthew 1904) and *M.* near *necatus* from Ricardo, California. On the other hand, another series of specimens from the Ricardo and *M. necatus* from the Barstow formations slightly surpass the Avawatz material in size.

Discussion of nomenclature—The single antilocaprid species in the Avawatz fauna is referred to *Merycodus* cf. *cerroensis* (Frick). In a recent publication (Frick 1937) the status of the genus *Merycodus* is questioned. Frick states (p. 276): "The genotypic species, *Merycodus necatus* Leidy

(1854), was based on fragmental and indefinitely characterized teeth from the Bijou Hills and remains indeterminate." He further states, "The Merycodontini are divided between three main—*Ramoceros* n.g., *Cosoryx* Leidy, and *Meryceros*, n.g.—and several minor groups . . . it is impossible as yet to determine which of these groups is represented by the lost type of *Merycodus* Leidy." Yet in at least three citations (pp. 292, 315, and 334) Frick expresses his conviction that *Merycodus* may "prove to be synonymous with" *Cosoryx*, and on two occasions (pp. 345 and 408) he definitely refers to *Cosoryx* some material which was originally identified as belonging to the genus *Merycodus*. Not once does Frick suggest that material previously referred to *Merycodus* might actually belong to one of the major or minor groups of the Merycodontini other than *Cosoryx*.

To be sure, as Frick points out, the original type was very inadequately characterized in Leidy's description of material from Bijou Hill (Leidy 1854). A few years later, however, Leidy without the slightest hesitation refers some excellent material from the Niobrara back to his original type (Leidy 1869). This material, more complete than the original type, Leidy described and illustrated in detail. It is to this later description that subsequent authors have turned again and again for the type species of the genus. Thus, though never formally defined as such, the material referred by Leidy in 1869 to the genus *Merycodus* is essentially the hypotype [1] of the genus.

A minor argument proposed by Frick in favor of dropping the genus *Merycodus* consists in the fact that at present the type material cannot be located. Obviously, the temporary misplacement or even complete loss of a type specimen cannot render a genus invalid, though, indeed, it may make comparison with the type somewhat difficult. It must be borne in mind that "a generic category can have, in the final analysis, only a single type, which is a species, and not, as many have thought, a specimen . . ." (Schenk and McMasters 1936). It is important to recognize that the species, being intangible, is not lost, and hence the genus *Merycodus* cannot be discarded. The only loss is the type specimen for the species. To rectify this, a neotype, providing that more material can be obtained at Bijou Hill, or a neoholotype [2] from another locality should be set up. It is the contention of the present writer that the material described by Leidy in 1869 fulfills just such a category.

While the above arguments for retention of the genus *Merycodus* are academic at best, there exists one very important point of practical significance in favor of retaining that generic name, namely that of precedent and past usage. Only confusion of the literature can result from the substitution of *Cosoryx* for *Merycodus*.

Relationships—Since the presence of a long diastema and reduction of the premolars, both upper and lower, are regarded as progressive characters, the merycodont from the Avawatz must be regarded as an advanced form. Lengthening of the molar tooth crowns likewise has reached an advanced stage, being considerably greater than in specimens from the Barstow and Cuyama and slightly less than in the Ricardo types. To what extent the form and pattern of $P\bar{4}$ may be used in determining the stage of advancement remains uncertain. In the position of the frontoparietal suture, rela-

[1] Hypotype: a described or figured specimen, used in publication in extending or correcting the knowledge of a previously defined species (see Frizzell 1933).

[2] Neoholotype: a new holotype selected by a subsequent worker in the event of loss of the original type material (see Frizzell 1933).

tively close behind the horn core pedicles, the Avawatz merycodont is definitely not so advanced as either the Barstow or the Ricardo forms. Horn cores similar to the Avawatz material have been found in both Ricardo and Barstow deposits (horizons unknown).

With due consideration of these evolutionary characters, the conclusion is reached that the merycodont from the Avawatz Mountains represents a species considerably more advanced than those from the Barstow and Cuyama and slightly less advanced than that from the Ricardo. In every way the species appears to be nearly related to *Merycodus cerroensis* (Frick) from Round Mountain Quarry, New Mexico.

Measurements (in millimeters) and ratios

	No. 1997 C.I.T.	No. 1999 C.I.T.
Postsymphyseal diastema	36.0	
P$\overline{2}$–M$\overline{3}$, total length	51.4	
M$\overline{1}$–M$\overline{3}$, total length	36.0	
P$\overline{2}$–P$\overline{4}$, total length	15.4	
$\frac{M\overline{1}-M\overline{3}}{P\overline{2}-P\overline{4}}$ ratio	2.3	
$\frac{M\overline{3}\text{, anteroposterior diameter}}{\text{Postsymphyseal diastema}}$ ratio	0.48	
P$\overline{2}$, anteroposterior diameter	3.6	3.5
P$\overline{2}$, transverse diameter	1.6	1.4
P$\overline{3}$, anteroposterior diameter	5.3	
P$\overline{3}$, transverse diameter	2.4	2.0
P$\overline{4}$, anteroposterior diameter	6.4	
P$\overline{4}$, transverse diameter	3.0	
M$\overline{1}$, anteroposterior diameter	8.9	8.9
M$\overline{1}$, transverse diameter	5.3	3.9
M$\overline{2}$, anteroposterior diameter	11.4	11.5
M$\overline{2}$, transverse diameter	5.9	3*
M$\overline{3}$, anteroposterior diameter	17.3	
M$\overline{3}$, transverse diameter	4.7	
Dm$\overline{4}$, anteroposterior diameter		8.0
Dm$\overline{4}$, transverse diameter		3.9

	No. 1995 C.I.T.	No. 1996 C.I.T.
P$\underline{2}$–M$\underline{3}$, total length	42.8	
P$\underline{2}$, anteroposterior diameter	4.6	
P$\underline{2}$, transverse diameter	2.5	
P$\underline{3}$, anteroposterior diameter	5.2	
P$\underline{3}$, transverse diameter	3.0	
P$\underline{4}$, anteroposterior diameter	5.9	
P$\underline{4}$, transverse diameter	3.7	
M$\underline{1}$, anteroposterior diameter	8.2	8.7
M$\underline{1}$, transverse diameter	5.8	6.4
M$\underline{2}$, anteroposterior diameter	11.0	9.3*
M$\underline{2}$, transverse diameter	6.3	5.9
M$\underline{3}$, anteroposterior diameter	9.5	
M$\underline{3}$, transverse diameter	5.0	
Dm$\underline{4}$, anteroposterior diameter		6.5
Dm$\underline{4}$, transverse diameter		4.5

* Partially erupted.

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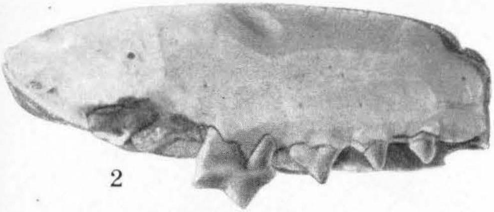
Aerial photograph of the southeastern flanks of the Avawatz Mountains, California. Quartzite and white marble intruded by darker igneous rocks make up the basement complex. Near the range and in the background the Tertiary sediments dip regularly off the basement complex. In the foreground and to the left the Tertiary sediments are closely folded and faulted.

Plate 2

Fig. 1—*Pseudælurus intrepidus* Leidy. No. 2309, left ramus, lateral view. ×1.
Fig. 1*a*—*Pseudælurus intrepidus* Leidy. No. 2309, left ramus, occlusal view. ×1.
Fig. 2—Canid, indet. No. 2308, right maxillary dentition, lateral view. ×1.
Fig. 2*a*—Canid, indet. No. 2308, right maxillary dentition, occlusal view. ×1.
Fig. 3—*Trilophodon* cf. *simplicidens* Osborn. No. 1984, mandible, occlusal view. ×¼.
Fig. 4—*Pliohippus ?*, sp. No. 2313, lower incisors and canines, occlusal view. ×1.
Fig. 5—*Pliohippus ?*, sp. No. 2312, $M\underline{1}$, occlusal view. ×1.

Calif. Inst. Tech. Vert. Pale. Coll.
Lower Pliocene, Avawatz Mountains, California.



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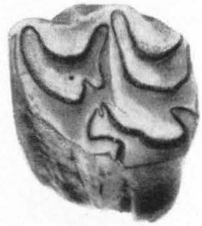

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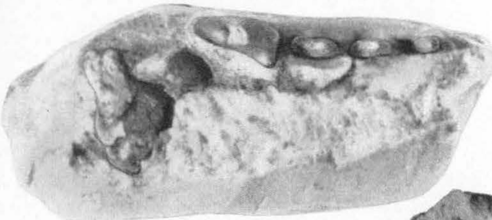

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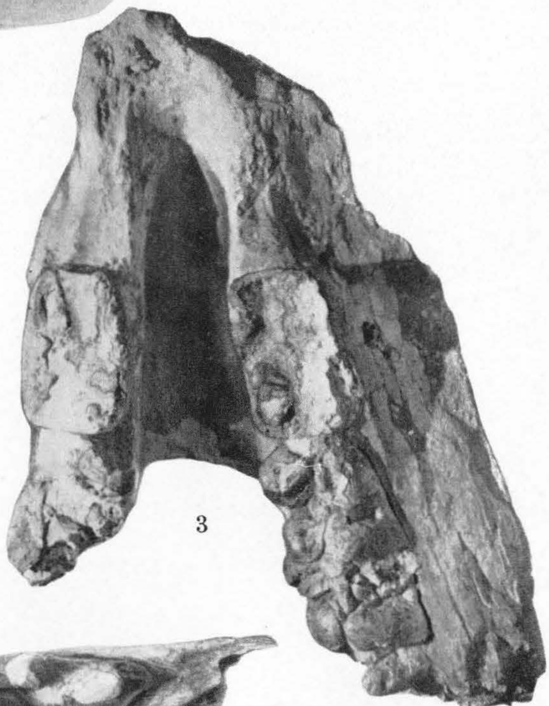

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PLATE 3

FIG. 1—*Procamelus coartatus* Stirton. No. 1989, palate with dentition, occlusal view. ×¾.

FIG. 2—*Procamelus coartatus* Stirton. No. 2316, left ramus, P$\overline{3}$–M$\overline{2}$, lingual view. ×¾.

FIG. 3—*Procamelus coartatus* Stirton. No. 2318, right ramus, M$\overline{2}$–M$\overline{3}$, lateral view. ×¾.

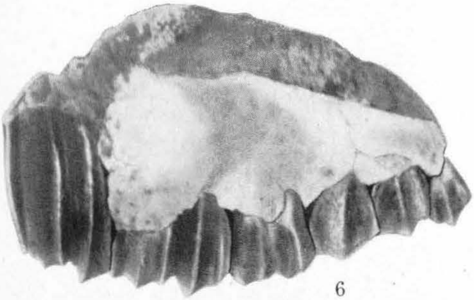
FIG. 4—*Procamelus coartatus* Stirton. No. 2319, Dm$\overline{4}$, lateral view. ×¾.

FIG. 5—*Procamelus coartatus* Stirton. No. 2317, M$\overline{2}$, lateral view. ×¾.

FIG. 6—*Merycodus* cf. *cerroensis* (Frick). No. 1995, right maxillary dentition, P$\underline{2}$–M$\underline{3}$, lateral view. ×1½.

FIG. 6*a*—*Merycodus* cf. *cerroensis* (Frick). No. 1995, right maxillary dentition, P$\underline{2}$–M$\underline{3}$, occlusal view. ×1½.

Calif. Inst. Tech. Vert. Pale. Coll.
Lower Pliocene, Avawatz Mountains, California.



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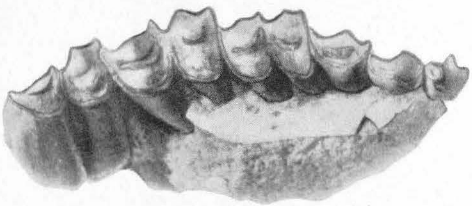

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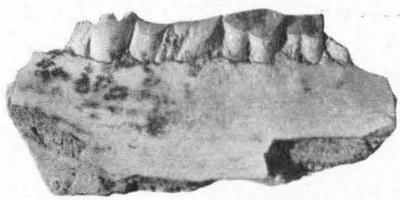

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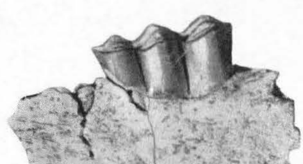

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Plate 4

Fig. 1—*Procamelus coartatus* Stirton. No. 2324, proximal end of radius, anterior view. ×½.

Fig. 1*a*—*Procamelus coartatus* Stirton. No. 2324, proximal end of radius, superior view. ×½.

Fig. 2—*Procamelus coartatus* Stirton. No. 2334, medial phalanx, anterior view. ×½.

Fig. 3—*Procamelus coartatus* Stirton. No. 2321, mandibular symphysis, ventral view. ×½.

Fig. 4—*Procamelus coartatus* Stirton. No. 2328, distal end of tibia, posterior view. ×½.

Fig. 4*a*—*Procamelus coartatus* Stirton. No. 2328, distal end of tibia, inferior view. ×½.

Fig. 5—*Procamelus coartatus* Stirton. No. 2325, distal end of radius-ulna, anterior view. ×½.

Fig. 5*a*—*Procamelus coartatus* Stirton. No. 2325, distal end of radius-ulna, inferior view. ×½.

Fig. 6—*Procamelus coartatus* Stirton. No. 2329, cannon bone, anterior view. ×½.

Fig. 7—Camelid, sp. No. 2336, distal end of tibia, posterior view. ×½.

Fig. 8—Camelid, sp. No. 2340, proximal phalanx, anterior view. ×½.

Calif. Inst. Tech. Vert. Pale. Coll.
Lower Pliocene, Avawatz Mountains, California.

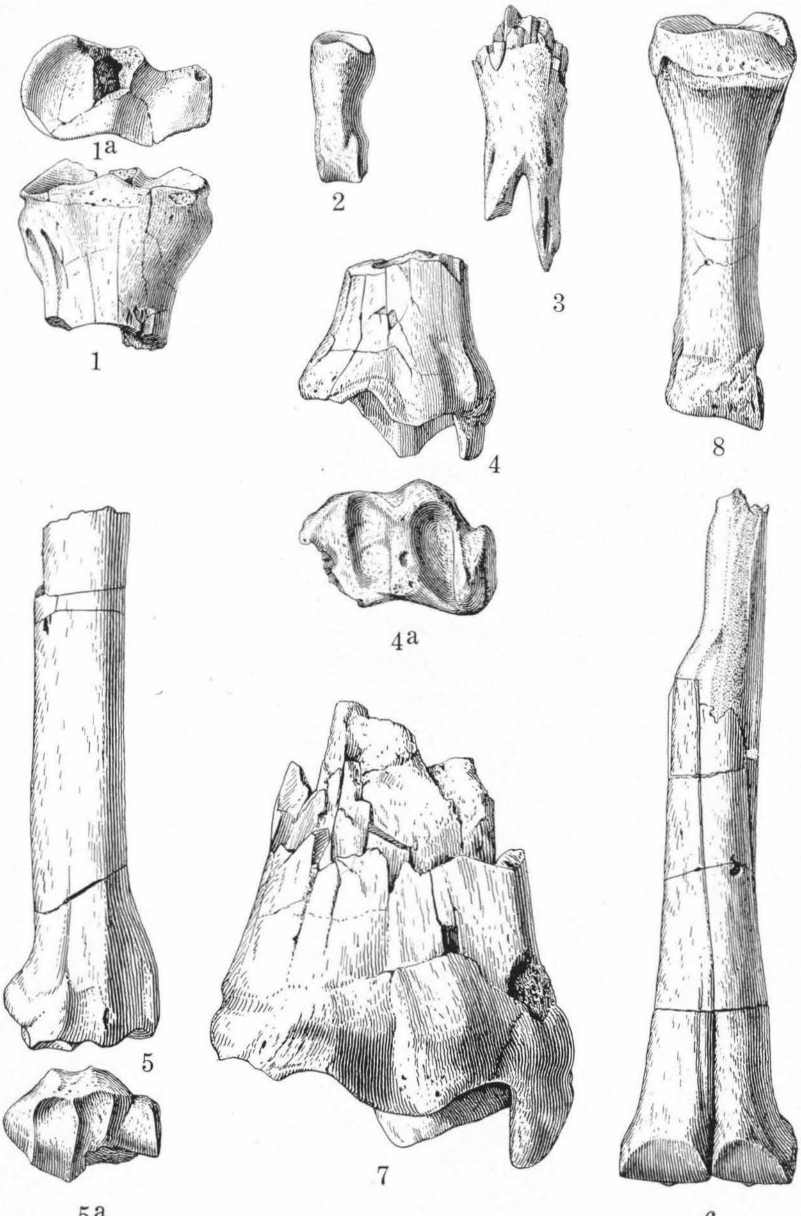
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Plate 4

Fig. 1—*Procamelus coartatus* Stirton. No. 2324, proximal end of radius, anterior view. ×½.

Fig. 1*a*—*Procamelus coartatus* Stirton. No. 2324, proximal end of radius, superior view. ×½.

Fig. 2—*Procamelus coartatus* Stirton. No. 2334, medial phalanx, anterior view. ×½.

Fig. 3—*Procamelus coartatus* Stirton. No. 2321, mandibular symphysis, ventral view. ×½.

Fig. 4—*Procamelus coartatus* Stirton. No. 2328, distal end of tibia, posterior view. ×½.

Fig. 4*a*—*Procamelus coartatus* Stirton. No. 2328, distal end of tibia, inferior view. ×½.

Fig. 5—*Procamelus coartatus* Stirton. No. 2325, distal end of radius-ulna, anterior view. ×½.

Fig. 5*a*—*Procamelus coartatus* Stirton. No. 2325, distal end of radius-ulna, inferior view. ×½.

Fig. 6—*Procamelus coartatus* Stirton. No. 2329, cannon bone, anterior view. ×½.

Fig. 7—Camelid, sp. No. 2336, distal end of tibia, posterior view. ×½.

Fig. 8—Camelid, sp. No. 2340, proximal phalanx, anterior view. ×½.

Calif. Inst. Tech. Vert. Pale. Coll.
Lower Pliocene, Avawatz Mountains, California.

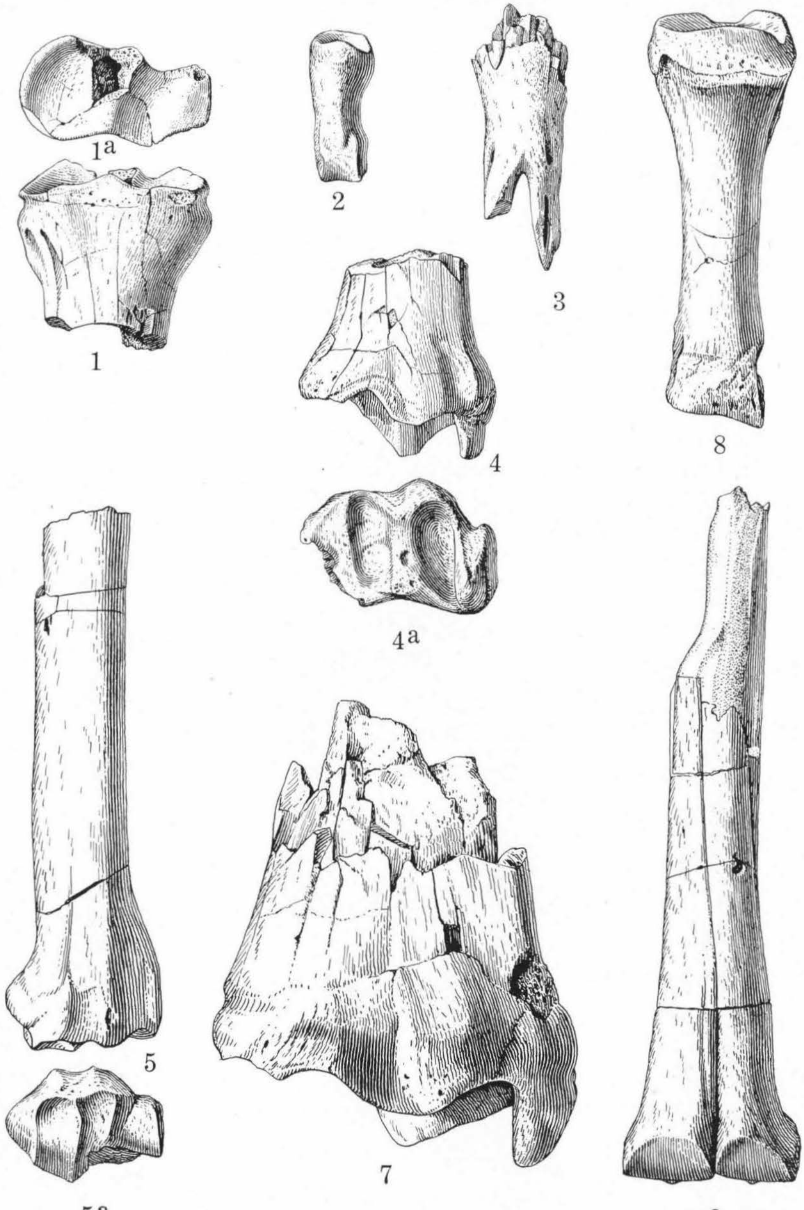
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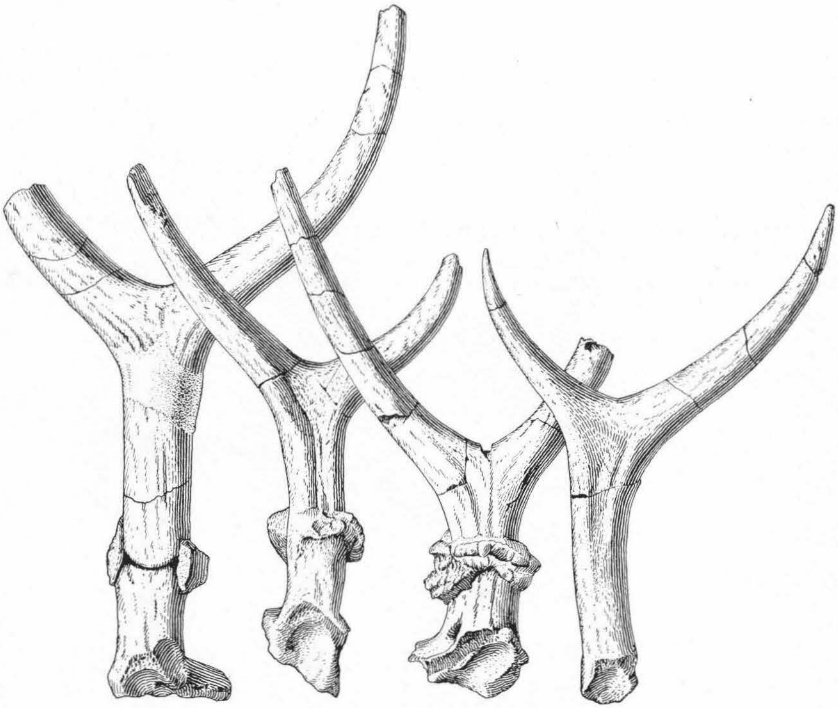
PLATE 5

FIGS. *a*, *b*, *c*, *d*—*Merycodus* cf. *cerroensis* (Frick). Nos. 1992, 1994, 1993, and 1991, horn cores, oblique view. ×½.

Calif. Inst. Tech. Vert. Pale. Coll.
Lower Pliocene, Avawatz Mountains, California.



a b c d

PLATE 6

FIG. 1—*Merycodus* cf. *cerroensis* (Frick). No. 1990, frontlet with horn cores, anterior view. ×½.

FIG. 1*a*—*Merycodus* cf. *cerroensis* (Frick). No. 1990, frontlet with horn cores, lateral view. ×½.

FIG. 2—*Merycodus* cf. *cerroensis* (Frick). No. 1997, left ramus, $P\bar{2}$–$M\bar{3}$, lateral view. ×1.

FIG. 2*a*—*Merycodus* cf. *cerroensis* (Frick). No. 1997, left ramus, $P\bar{2}$–$M\bar{3}$, occlusal view. ×1.

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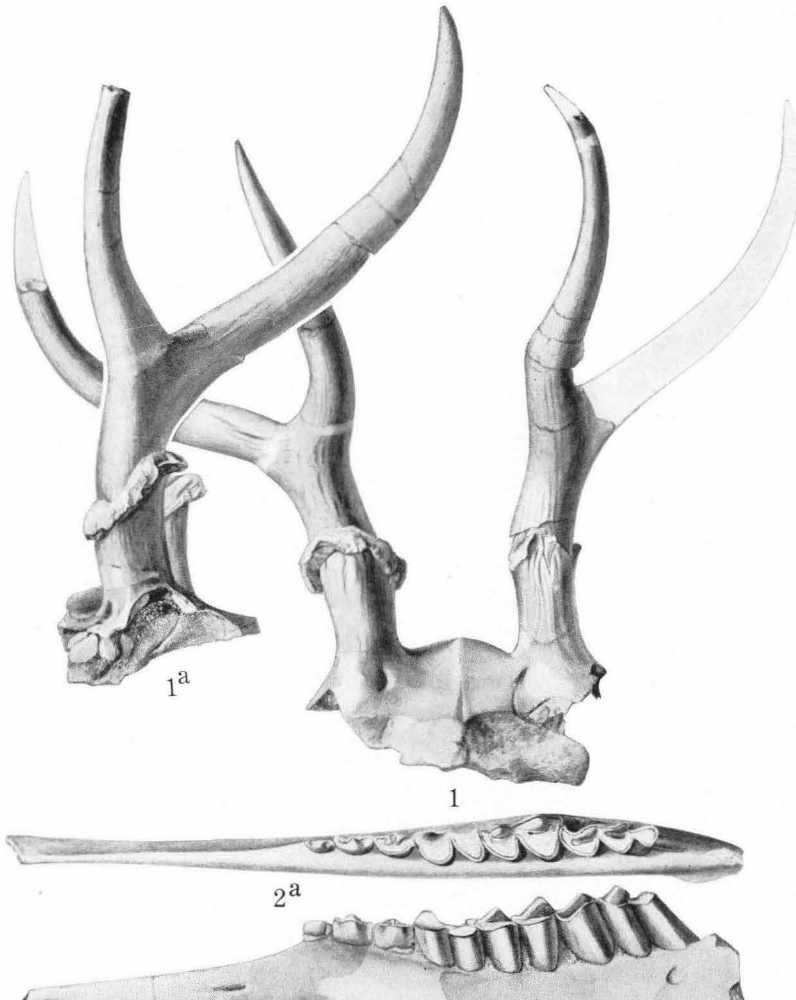
1^a
1
2^a
2